Singing Propellers

A HydroComp Technical Report
Report 138

Overview

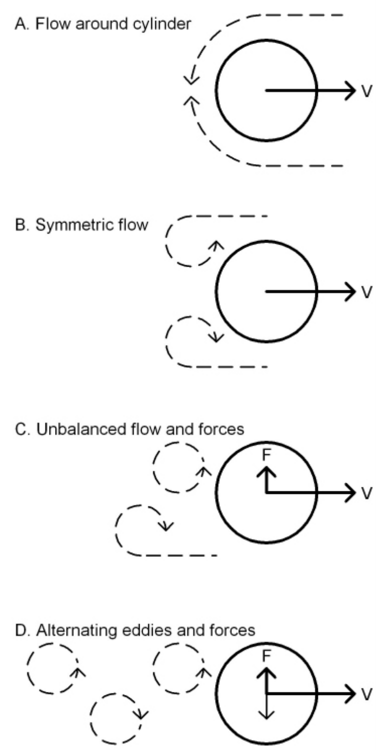
Some propellers in service produce a high-pitched noise, often referred to as *singing*. This sound typically is a clear harmonic tone much like that of a ringing wine glass. (Other sounds, which have been attributed to singing, have been characterized as “grunting” or “sawing”. These sounds are most likely different in nature than the ringing tone considered here.)

More of an annoyance than anything harmful, the causes of singing are not completely understood. This report will try to introduce what – in our opinion – is the likely cause of singing, as well as to offer some guidance regarding ways to eliminate singing from a propeller.

Fluid circulation and vortex shedding

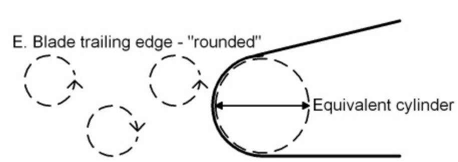
Have you ever been driving in an automobile and their vertical radio antenna begins to vibrate and produce a sound? If so, the tone you heard was caused by the way fluid (air, in this case) will circulate around the rod and set up alternating eddies. The pitch of the tone is the frequency of these alternating vortices.

Consider the accompanying graphics, which illustrate the development of the tone. Fluid flow starts to curl around the body (A). Eddies (vortices) are created behind the body (B). Any asymmetry in the flow direction or in the shape of the body will cause the separating vortices to set up sequential eddies. The force of the unbalanced vortex on the body will impart a sideways force on the body – further promoting flow and shape asymmetry, and the development of alternating vortices (C). Finally, a well-behaved system of alternating eddies and forces is established, resulting in the audible tone of singing that we hear (D).



The propeller trailing edge as the singing body

The basis of using this model for propeller singing is that a rounded trailing edge corresponds to the circular body – an “equivalent cylinder” of sorts. This is illustrated in the graphic below (E).



Prediction of possible singing

The vortex-trail frequency – the sound you hear from a singing body – can be predicted using a non-dimensional coefficient called the *Strouhal number*.

$$Sn = f * d / \upsilon \quad \text{or,} \quad f = Sn * \upsilon / d$$

where,

Sn = Strouhal number
f = audible frequency [Hz]
d = effective diameter of rounded trailing edge
υ = kinematic viscosity of water

Strouhal number can be related to the local Reynolds number of the trailing edge effective diameter [Saunders, 1957]. This relationship was presented as a graph in the reference, but we have prepared the following numerical formula of the plot.

$$Sn = 10^{\left[\frac{0.2617 - 0.03919k}{1 - 0.000503k - 0.02589k^2}\right]}$$

where,

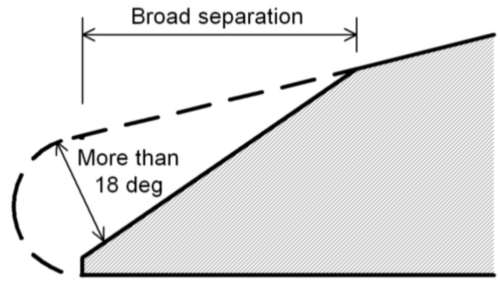
Sn = Strouhal number
$k = \log_{10}(Rn_d)$
$Rn_d = v_{blade} * d / \upsilon$
$v_{blade} = [v_{ship}^2 + (0.7*\pi*D*n)^2]^{0.5}$
D = propeller diameter
n = propeller revolutions

It has been suggested that the practical frequency range of audible singing is approximately from 10 to 1200 Hz, although the audible range could be as high as 12,000 Hz [Saunders, 1957]. Therefore, we can use the Reynolds number of the effective edge diameter to find the Strouhal number, which in turn is used to predict if the frequency might be audible.

Mitigation of singing

These relationships also tell us that singing is a function of propeller diameter and rpm, boat speed, and trailing-edge size (thickness) and "roundness". We cannot do much about diameter, rpm or speed, but we can modify the edge geometry. This has been the strategy for all efforts to eliminate singing.

Most propeller professionals (and others) are familiar with the "anti-singing edge" – a chamfering of the trailing edge, typically on the suction side. The intent of this shape is to avoid the creation of curving flow eddies by cleanly separating the flow off of the blade. The following graphic illustrates the desired geometry of an anti-singing edge, where points of flow separation are spaced both in thickness and in flow-stream position [Saunders, 1957].



Many sources recommend that the anti-singing edge be applied from the 40% radius (0.4R) fully to the tip, or even slightly beyond [Carlton, 1993]. It has also been noted that erosion of the blade edge is a risk if the new edge were made too thin.

There is also some evidence that cup can be an effective anti-singing technique. Cupping, however, changes the thrust and power characteristics of the propeller, where an "anti-singing edge" would not measurably alter performance.

References

Carlton, J.S. and Fitzsimmons, P.A.; "Hydrodynamic aspects of ship propulsion – results of service experience", *Transactions IME*, Vol. 105, Part 4, 1993.

Saunders, H.E, *Hydrodynamics in Ship Design*, SNAME, 1957.

HydroComp, Inc.
13 Jenkins Court, Suite 200
Durham, NH 03824 USA
Tel (603)868-3344
Fax (603)868-3366
info@hydrocompinc.com
www.hydrocompinc.com